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SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Draft Staff Report

Proposed Amended Rule 1112.1 – Emissions Of Particulate Matter and Carbon Monoxide from Cement Kilns

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EXECUTIVE SUMMARY

Currently, California Portland Cement Company (CPCC), is the only company in the SCAQMD that manufactures Gray Portland Cement (cement). The company is located in Colton, in San Bernardino County. Cement is used primarily as a construction material in the industrial sector due to the strength and durability of the product. It is currently being manufactured in two kilns at Colton, Kiln #1 and Kiln #2. The production process results in a variety of kiln emissions including CO and NOx. CPCC has come up with an emissions control strategy for mitigating NOx. The process involves injection of used tires into the kiln which lowers the oxygen concentration while maintaining the kiln combustion dynamics. While the process modifications at CPCC have had a beneficial impact in reducing overall CO emissions as well, it does occasionally result in increased CO formation over brief periods of time, exceeding the Rule 407 CO emissions limit of 2,000 ppm averaged over 15 consecutive minutes. The purpose of the proposed rule amendment is to acknowledge the air quality benefit by CPCC reducing NOx emissions and establish an alternative emission limit for cement kilns by extending the averaging time period for kiln CO emissions and an annual mass CO emissions limit that ensures air quality standards and local ambient air quality are not compromised. The reduction of NOx emissions is a priority since it is a precursor of both PM10 and ozone. There have been no violations of the CO standard in the AQMD since 2002 and prior to that only a small upwind portion of south Los Angeles County, far from the facility in San Bernardino County, periodically exceeded the CO standard. The region has recently been redesignated as attainment for the federal ambient CO standard by U.S. EPA. Also CO concentrations are localized near the source of emissions and do not have regional impacts as do some air contaminants. Conversely, the area surrounding CPCC is in non-attainment for both ozone and PM10. Staff proposes that Rule 1112.1 which specifically regulates cement kilns be amended to include an alternative CO standard of 2,000 ppm averaged over 3 hours and an annual mass emission reduction of CO from a 2003 baseline. Air quality modeling at CPCC indicates that ambient CO levels will not be adversely affected by the alternative kiln standard.

BACKGROUND

Purpose

CPCC is currently the only facility manufacturing cement in the SCAQMD. The facility is a RECLAIM source and has undertaken a program to reduce NOx from two on-site kilns. The process involves injection of used tires into the cement kiln. A consequence of this strategy is an increase in CO emissions over very brief periods, exceeding the current Rule 407(a)(1) CO threshold which reads:

> "(a) A person shall not discharge into the atmosphere from any equipment :
>
> (1) Carbon monoxide (CO) exceeding 2,000 ppm by volume measured on a dry basis, averaged over 15 consecutive minutes."

In support of the NOx reduction strategy CPCC has asked the District for assistance in structuring a compliance strategy for CO specific to cement kiln operations. Staff has examined an array of options including a combination of lowering the emissions threshold in conjunction with an increased averaging period. Staff is recommending amendments that will not cause or contribute to exceedences of either the one or eight hour state standards for CO and are not projected to have a significant impact on local ambient air quality. In addition the standard, compliance procedures, and test methods for CO will be more precisely defined. The reduction of NOx is emphasized over CO as NOx is a precursor to both ozone and PM10. Figures 1 through 4 show historical ambient air quality within the SCAQMD for ozone, PM10 and PM2.5, respectively.

Figure 1. Number of days the 1-hour federal OZONE standard (> 0.12 ppm) was exceeded in 2005

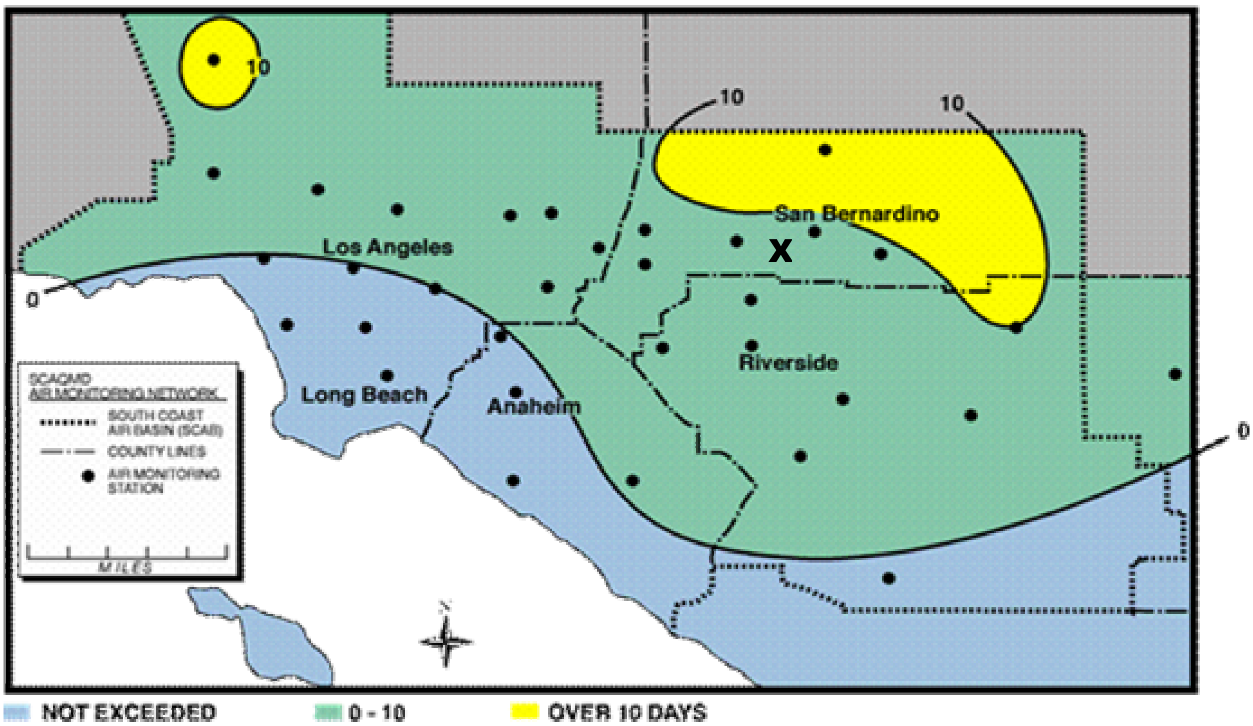


Figure 2. Number of days the 8-hour federal OZONE standard (> 0.08 ppm) was exceeded in 2005

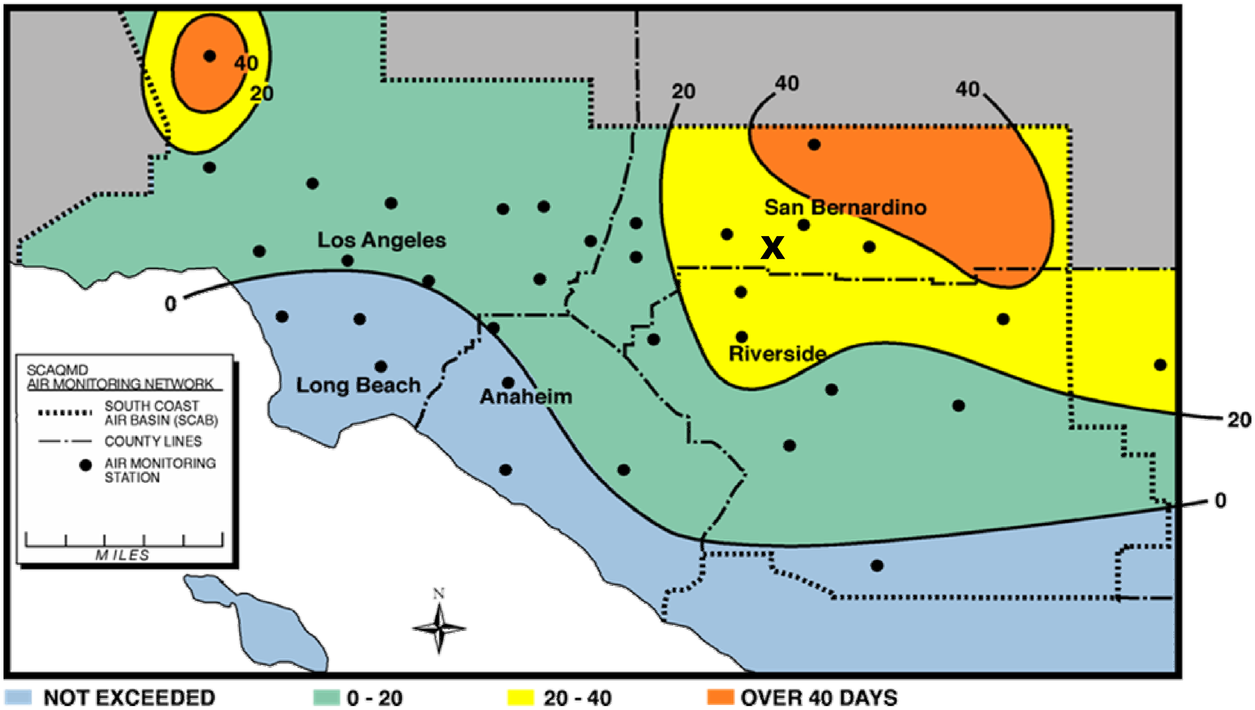


Figure 3. 2005 PM10 Annual Arithmetic Mean ($\mu g/m^3$) compared to 50 $\mu g/m^3$ federal standard

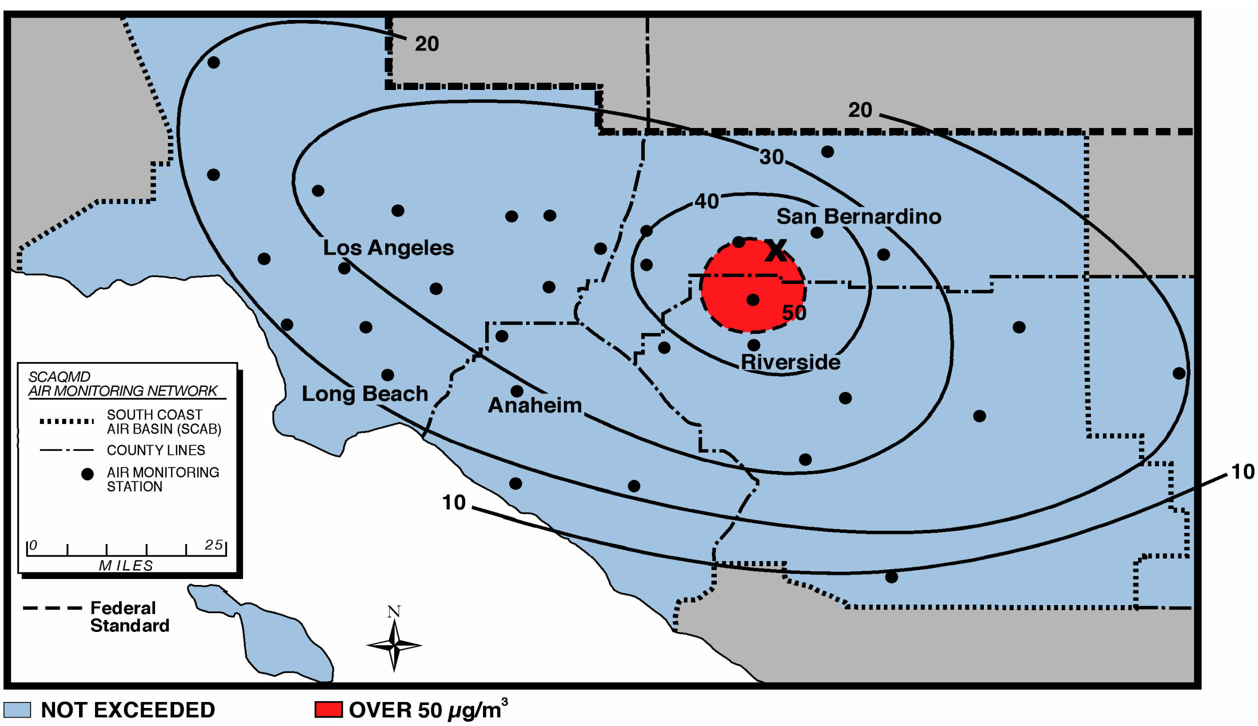
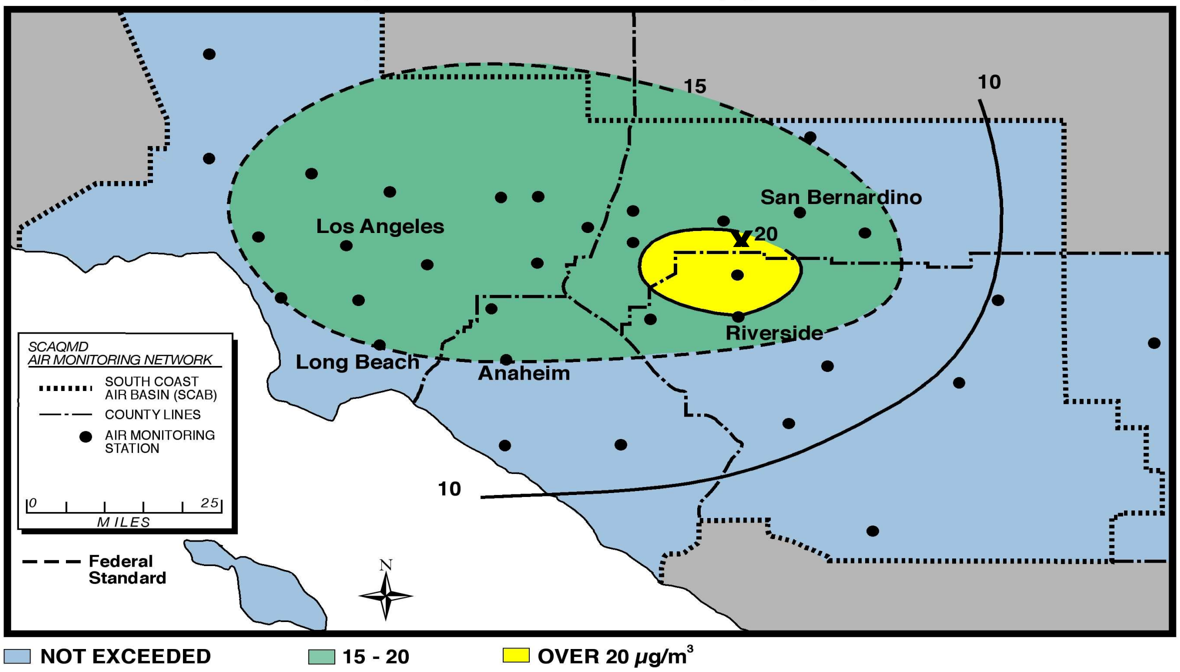


Figure 4. 2005 PM2.5 Annual Arithmetic Mean (µg/m^3) compared to 15 µg/m^3 federal standard



Exceedences for ozone, PM10 and PM2.5 were recorded throughout the basin with the highest concentrations occurring in the general area where the CPCC facility is located (as indicated by the symbol **X**). In contrast, the localized exceedance of CO has historically been confined to a limited area in south Los Angeles County. In 2005, for the third consecutive year since 2003, no areas in the Basin exceeded the CO air quality standards. The Basin has been officially designated as being in attainment with federal CO standards by U.S. EPA. The highest concentrations of CO continued to be recorded in the areas of Los Angeles County where vehicular traffic is most dense with the highest concentration continuing to be south central Los Angeles County, far upwind of CPCC. The highest 8-hour average CO concentration recorded for 2005 was 5.9 ppm, in the South Central Los Angeles County area, and was 62% of the federal CO standard.

In contrast, for 2005 the Basin exceeded federal and state standards for ozone, PM10 and PM2.5. For ozone, the maximum 1-hour average (0.182 ppm) and maximum 8-hour average (0.145 ppm) concentrations were both recorded in the central San Bernardino Mountains area to the north-east of CPCC and were 146% and 171% of the federal standard, respectively. The Central San Bernardino Mountains area recorded the greatest number of excedences (80 days) of both the state and federal 1-hour (18 days) and 8-hour (69 days) standards in addition to 7 days for the health advisory level (Figures 1 and 2).

For PM10, the maximum annual average concentration (52 μg/m^3) occurred in the Metropolitan Riverside County area, in the general vicinity of CPCC (Figure 3). For PM2.5 the maximum 24-hour average (132.7 μg/m^3) and annual average (21.0 μg/m^3) concentrations were recorded in the East San Gabriel Valley area and the Metropolitan Riverside County area, both in the general vicinity of CPCC, and were 203% and 139% of the federal standard, respectively. Figure 4 shows the 2005 PM2.5 Annual Arithmetic Mean concentration as compared to 15 μg/m^3 federal standard.

Furthermore, about 13% (154 tons/day) of the total annual total NOx inventory in the Basin is from stationary sources in contrast to only 1.4% (99 tons/day) from CO. The data indicates that efforts to mitigate ozone, PM10 and PM2.5, by controlling NOx and particulate emissions, remain the highest priority at CPCC..

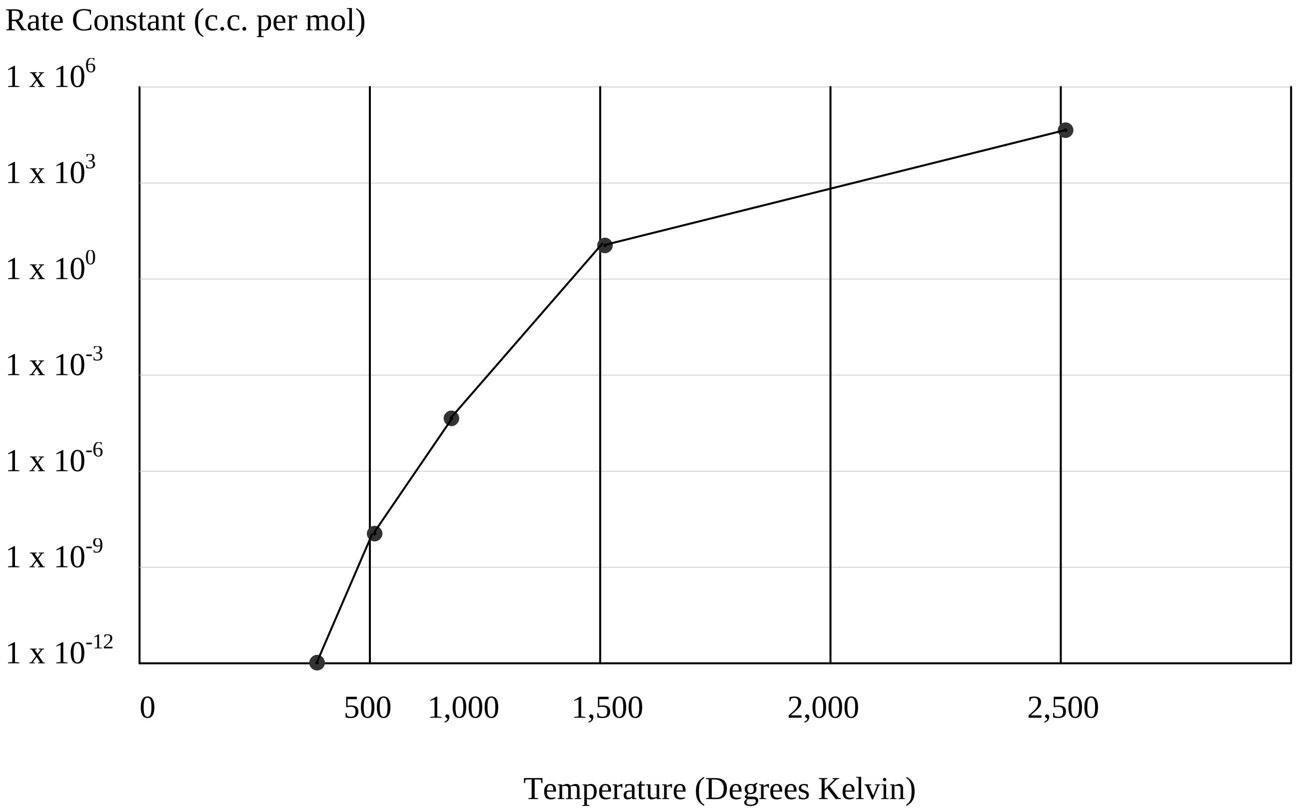
Portland Cement Manufacturing

The name Portland Cement (cement) refers to a process that was patented in 1824 and is not associated with any particular location or person. The process of manufacturing cement begins with the quarrying of "Raw Mix" which is predominantly limestone rock. Raw Mix is then refined through a series of mechanical grinding and crushing operations which not only segregate but significantly reduce the diameter of the component quarried materials. The segregated materials as well as other materials brought to the facility and used in the manufacturing process are stored in silo bins. From here, limestone, shale, iron ore and silica in proprietary proportions, or kiln mix, are pneumatically feed into the feed end of each kiln. It takes approximately 1.56 parts of this kiln feed to manufacture 1 part of Portland cement. Each kiln is basically a huge rotating cylinder lined with refractory fire brick that is several hundred feet long. A slight incline from the horizontal causes the spinning material in the kiln to travel down the length of the kiln from the feed end to the discharge end. A large burner located at the discharge end of the kiln fires the transitory kiln feed. Reaction zones are established towards the center and in towards the horizontal axis of the kiln as the feed mix is oxidized and the resulting reactions produce an intermediate product called clinker that is collected at the discharge end. Clinker is a harder material than any of the quarried rock that comprises the feed mix. In the final phase, the clinker is milled and packaged with gypsum to produce cement. Cement when mixed in the correct proportion with water sets to form concrete.

Carbon Monoxide Formation in Cement Kilns

Quarried limestone is not a homogenous material but is composed mostly of limestone which is also the principle ingredient for manufacturing cement. Limestone is predominantly Calcium Carbonate (CaCO3). The production of cement involves chemical reactions in which the feed mix in the kiln is heated to high temperatures and oxidation of the feed mix occurs. The oxidation of carbon compounds results in the formation of carbon monoxide (CO) and carbon dioxide (CO_2). Both are present to an extent in the kiln during clinker production. In the kiln, two factors influence the proportions of CO to CO_2. First, the amount of oxygen present and second, the temperature in the reaction zone of the kiln. In general, the more oxygen available the more carbon monoxide is reduced to carbon dioxide. Figure 8 shows that higher kiln temperatures tend to increase the oxidation of CO to CO_2.

Figure 8. Increasing Rate Constant for Oxidation of CO with Temperature



Factors Effecting Carbon Monoxide Formation

The production of cement also results in oxides of nitrogen (NOx) emissions. NOx emissions from kiln reactions are a byproduct of using air to feed the kiln, the fuel used, and the nature of the combustion process. Both NOx and CO result from the chemistry and temperature environment that occurs in the kiln process. The problem is that conditions favoring mitigation of NOx, namely limiting the presence of air and reducing peak combustion temperatures lead to increased CO emissions. Paradoxically, the converse also holds and the presence of excess air (or oxygen) and higher kiln temperatures increases the proportion of kiln NOx emissions. The tire injection NOx control strategy developed specifically for CPCC minimizes the presence of air while maintaining kiln temperatures by providing a packet of energy when the tire is burned in the kiln in an exothermic reaction. CO spiking can be mitigated with this approach. There are also practical limitations on the amount of excess air that could be introduced into the kiln process to address CO emissions. Too much air would be inefficient both in terms of the extra energy needed to drive the increased volume flow through the kiln and also because of the increased fuel needed to maintain optimal kiln temperatures.

TIME AVERAGING PERIOD MODELING FOR CPCC

Specific Factors

Both Kiln #1 and Kiln #2 are analogous to extremely immense crucibles where a myriad of chemical reactions are continuously taking place. In addition, because of the design and enormous dimensions of each kiln, different reactions are taking place at the same time in different areas or zones of the kiln. Kiln feed composition and temperature can vary unpredictably within the kilns. Temperature while tending to increase towards the core of the kiln does so in a non-uniform manner. The variability in kiln feed mix composition and temperatures necessitate continuous oversight. Because of the proportions of each kiln, much can happen in the formation process of Clinker from the time feed mix enters the kiln at the feed end till it exits the kiln at the discharge end as Clinker.

A kiln operator monitors the kiln processes in real time from a remote location and makes adjustments to burner flame temperature and the other reaction variables as necessary. Even though the process is monitored in real time, the effect of any operator action can take up to twenty minutes to take place in the kiln. Variations in temperature and kiln feed mix composition sometimes lead to the formation of both “dams” and “fronts”. A dam is formed when molten feed mix cools enough to solidify, creating a dam like barrier behind which molten feed mix accumulates. In order to re-establish the flow of kiln feed material towards the discharge end of the kiln the operator must generally increase temperatures in the kiln. Even measured corrections deviate from anticipated outcomes because of the size, complexity and uncertainty of kiln operations. Eliminating a dam by increasing kiln temperatures may release an accumulation of liquefied feed mix from behind the dam. This can rush towards the discharge end creating a front or wave. A front results in the reacting kiln mixture moving faster than the desired residency time for an optimal reaction. Waves and fronts are a major concern in stabilizing kiln reactions. The experienced operator’s job is more anticipating how the kiln will be reacting some time in the future, in real time, and working to maintain optimal kiln conditions. In empirical observations made during site visits to CPCC and in discussions with operational and management staff the following factors were found to affect CO emissions from kilns:

1. The non-homogenous chemical composition of raw mix and hence the feed mix,
2. The varying temperatures in various reaction zones within the kilns,
3. The heterogeneous chemical composition of tires used in the injection system, and
4. The uncertain distribution of reaction zones within the kilns leading to the formation of “dams” and “fronts”.

While each kiln normally operates within a known range of settings, uncertainty about the above factors results in uncertainty about CO emissions.

Historical Data and Analysis

Raw data provided by CPCC is in the form of time averaged data from continuous emissions monitors operating on both Kiln #1 and Kiln #2, in excel file format (the CO monitors operated by CPCC have not been certified by the SCAQMD). Over two years of representative data, from 2005 through to early 2007, was used for modeling of kiln CO emissions. Since the data is in the form of actual real time observations of both kilns under operating parameters, the observations were modeled using various rolling average time periods. Each rolling average time period was representative of a target time averaging period for CO emissions concentrations measured in ppm corrected to 3% O_2, on a dry basis. No more than 30 minutes is usually required to average 2,000 ppm or less, however there are rare excursions to almost 2,400 ppm. Since the averaging period needed to remain in compliance has generally dropped with time, some of the longer compliance averaging periods required, especially in earlier years could be attributed to breakdowns, repair and testing, equipment replacement and/or new operator inexperience as potential reasons. Data and analysis of almost 18,000 data points indicates that CO compliance can be achieved with a time averaging period of 3 hours at 2,000 ppm, corrected to 3% O2, on a dry basis. The data and resultant time emissions period is summarized in the following table:

Table 1. Data and Resultant Time Averaging Period for Kiln Observations

Statistic	Kiln #1	Kiln #2
Observations/Data Points	17,985	17,986
Observation period	1/1/2005 – 2/1/2007	1/1/2005 – 2/1/2007
Maximum observation (ppm CO)	2,291	2,354
Proposed time averaging period (hours)*	3	3

*averaged CO concentration not to exceed 2,000 ppm, corrected to 3% O_2, on a dry basis

Data provided by CPCC also shows a general decrease in mass CO emissions for the past four years as shown below:

Table 2. Annual Mass Emissions (tons/year)

Year	Kiln #1	Kiln #1 Reduction**	Kiln #2	Kiln #2 Reduction**
2003	5,114	-	4,226	-
2004	3,126	39%	3,037	28%
2005	1,100	79%	1,132	73%
2006	1,005	80%	1,269	73%

**the % reduction in kiln emissions form the base year in 2003 (rounded to nearest 1%)

Based on the above trend and continued future mandatory NOx reductions, staff also recommends that the annual combined total of all CO emissions from both kilns be limited to no more than 50% per calendar year of the combined total 2003 baseline CO emissions from both kilns.

Ambient Air Quality and Dispersion Modeling

Currently, Rule 407 has a general CO emission limit for permitted equipment of 2000 ppm averaged over 15 minutes. The proposal is to make a CO limit for cement kilns in Rule 1112.1, which would be 2000 ppm emission limit averaged over 3 hours. Dispersion modeling was performed to assess the impacts of the proposed change to the 1-hour and 8-hour CO concentrations. The U.S. EPA model, called ISCST3, was used with a radial receptor grid. Meteorological data at the AQMD's Riverside meteorological site was used as input to the dispersion model. The worst-case CO air quality over the period 2004 to 2006 at the San Bernardino monitoring site (Station No. 5203) was assumed to represent background CO air quality. The assumed CO emission rates and stack parameters for the modeling are summarized in Table 1. The highest 1-hour CO value over the period January 1, 2005 to February 1, 2007 from each of the kiln stacks' continuous emission monitors (CEM) was used for the 1-hour emission rates in Table 1. The proposed rule limit of 2,000 ppm was assumed for the 8-hour emission rates in Table 1.

Table 1. Emissions and Stack Data Used in the Dispersion Modeling.

Stack Parameters	Kiln Stack #1	Kiln Stack #2
Stack height (m)	29.6	29.6
Stack diameter (m)	3.5	3.5
Stack temperature (degrees K)	444.3 – 452.0*	452.0 – 453.7*
Stack gas exit velocity (m/s)	20.5 – 21.9*	13.3 – 29.2*
1-hour CO emission rate (g/s)	10.5	14.0
8-hour CO emission rate (g/s)	8.4	5.4

* Stack temperature and stack gas exit velocity depends on the averaging period (i.e., 1-hour or 8-hour)

The modeling results are shown in Table 2. Since the project impact area is in attainment of all state and federal CO ambient air quality standards, the project increment is added to the worst-case background concentrations and the sum compared to relevant CO standards. As shown in Table 2, the total impacts are well below all state and federal ambient air quality standards. Also, note that the project increments are less than seven percent of the Rule 1303 CO significance thresholds.

Table 2. Dispersion Modeling Results.

Averaging Time	Project Increment ($\mu g/m^3$)	Background Air Quality ($\mu g/m^3$)	Total Concentration ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)	CAAQS ($\mu g/m^3$)	Rule 1303 Significance Thresholds ($\mu g/m^3$)
1-hour	66.9	4,600	4,667	40,000	23,000	1,100
8-hour	26.8	3,795	3,822	10,000	10,000	500

NAAQS = national ambient air quality standards
CAAQS = California ambient air quality standards

PROPOSED AMENDMENT

Staff is recommending that Rule 1112.1 be amended to include CO limits as well as the current particulate limits. For CO two alternatives are offered; comply with the current limit of Rule 407(a)(1) or as an alternative comply with a new proposed standard of 2,000 ppm concentration limit averaged over 3 hours plus annual CO emissions from a kiln cannot exceed 50% of the baseline 2003 CO emission.

Proposed amendments also include text on updating compliance procedures and test methods to conform with the certification requirements of Rule 218.

CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)

Pursuant to California Environmental Quality Act (CEQA) Guidelines §15252 and SCAQMD Rule 110, the SCAQMD has prepared an Environmental Assessment (EA) for the adoption of proposed amended Rule 1112.1. The Draft EA concluded that implementation of the proposed project would not result in significant adverse environmental impacts. The Draft EA was released for a 30-day public review and comment period from July 17, 2007 to August 15, 2007. The Draft EA is available at AQMD headquarters, or by calling the AQMD Public Information Center at (909) 396-3600, or by accessing AQMD's CEQA website at http://www.aqmd.gov/ceqa/aqmd.html.

SOCIO-ECONOMIC ISSUES

The proposed amendments to Rule 1112.1 do not significantly affect air quality or emission limitations and therefore a socioeconomic impact analysis pursuant to California Health and Safety Code Section 40440.8 is not required.

LEGISLATIVE AUTHORITY

The California Legislature created the AQMD in 1977 (The Lewis-Presley Air Quality Management Act, Health and Safety Code Section 40400 et seq.) as the agency responsible for developing and enforcing air pollution control rules and regulations in the Basin. By statute, the AQMD is required to adopt an Air Quality Management Plan (AQMP) demonstrating compliance with all state and federal ambient air quality standards for the Basin [California

Health and Safety Code Section 40460(a)]. Furthermore, the AQMD must adopt rules and regulations that carry out the AQMP [California Health and Safety Code Section 40440(a)].

DRAFT FINDINGS

Before adopting, amending, or repealing a rule, the California Health and Safety Code Section 40727 requires the AQMD to adopt written findings of necessity, authority, clarity, consistency, non-duplication, and reference based on relevant information presented at the public hearing and in the staff report.

Necessity - The AQMD Governing Board has determined that a need exists to amend Rule 1112.1 – Emissions of Particulate Matter and Carbon Monoxide form Cement Kilns, to allow an alternative CO concentration standard for grey cement kilns provided there is a concurrent reduction in mass annual CO emissions.

Authority - The AQMD Governing Board obtains its authority to adopt, amend, or repeal rules and regulations from the California Health and Safety Code Sections 39002, 39650, 40000, 40001, 40440, 40702, 41508, and 41700, et seq.

Clarity - The AQMD Governing Board has determined that the proposed amendment to Rule 1112.1 is written or displayed so that its meaning can be easily understood by the persons directly affected by it.

Consistency - The AQMD Governing Board has determined that Proposed Amended Rule 1112.1 is in harmony with, and not in conflict with or contradictory to, existing statutes, court decisions, federal or state regulations.

Non-Duplication Rule 1112.1 does not impose the same requirements as any existing state or federal regulations, and the proposed amended rule is necessary and proper to execute the powers and duties granted to, and imposed upon, the AQMD.

Reference - In adopting this regulation, the AQMD Governing Board references the following statutes which the AQMD hereby implements, interprets or makes specific: California Health and Safety Code Sections 40440(a) (rules to carry out the Air Quality Management Plan), and 40440(c) (cost-effectiveness), 41508, 41700 (nuisance), and Federal Clean Air Act Section 172(c)(1) (RACT).

AQMP AND LEGAL MANDATES

The California Health and Safety Code requires the AQMD to adopt an Air Quality Management Plan (AQMP) to meet state and federal ambient air quality standards with the South Coast Air Basin. In addition, California Health and Safety Code requires the AQMD to adopt rules and regulations that carry out the objectives of the AQMP. Although the goal of Control Measure PRC-07 of the 2003 AQMP is to further control VOC emissions from industrial processes and could apply to Rule 1112.1, the proposed amendments do not result in additional emission reductions; however the amendments are consistent with AQMP objectives.

This proposal does not impose a new emission limit or standard, make an existing emission limit or standard more stringent or impose new or more stringent monitoring, reporting or recordkeeping requirements and therefore is not subject to the comparative analysis provisions of California Health and Safety Code Section 40727.2.

COMMENTS AND RESPONSE TO COMMENTS

United States Environmental Protection Agency Comment

Comment: The District should delete 1112.1(b)(2)(A) as proposed which references the current CO standard in Rule 407 and instead amend Rule 407 specifically exempting cement kilns from the requirements of Rule 407.

Response: Rule 1112.1 as proposed provides the option of complying with the existing Rule 407 standard or the new proposed threshold standard of 2,000 ppm of CO averaged over three (3) hours if the total annual mass CO emissions are reduced by fifty percent (50%).This approach provides a clearer decision tree and for compliance verification.

California Air Resources Board Comment

Comment: Are there any localized CO impacts from increasing the averaging period for CO emissions?

Response: Dispersion modeling using U.S. EPA model ISCST3 with a radial receptor grid was used to assess the impacts of the proposed change to the 1-hour and 8-hour CO concentrations. Modeling results indicate that total impacts are well below all state and federal ambient air quality standards. In addition, the project increments are less than seven percent (7%) of the Rule 1303 CO significance thresholds. The localized impact of increasing the CO averaging time to three hours (3) would be negligible. In addition, under the optional standard mass emissions from the facility must be cut in half from the 2003 CO emissions baseline, thereby providing a net benefit.

Public and Stakeholder Comment

Comment: CPCC is continuing work on further reducing NOx emissions through experimental technologies, specifically by installation of mixing fans and aqueous ammonia injection. Since reduction of NOx has a much higher priority over CO is it possible to lower the required CO annual emission reduction to thirty percent (30%) of the 2003 baseline (instead of 50%) for the new proposed compliance option?

Response: The District supports the work being done by CPCC in further reducing NOx emissions. Data submitted by CPCC indicates that current kiln CO emissions have been reduced approximately seventy percent (70%) from the 2003 baseline. The selection of a fifty percent (50%) emissions reduction requirement in the current proposal provides for a twenty percent (20%) cushion so that CPCC will not be in violation while continuing efforts to further reduce NOx.

RECOMMENDATION

Adopt proposed amendments to Rule 1112.1 and certify the associated Final EA.